SOME ASPECTS REGARDING NOISE EXPOSURE DOSE MONITORING FOR WORKING PERSONNEL

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Abstract. *There are many situations where there is the need to accurately assess the risk of exposure to high noise levels and to monitor any employees who are exposed to potentially damaging noise. Framed both on health assurance, and human noise protection areas, this study try to dignify some particular aspects regarding the indoor noise exposure of working personnel. Based on multiple instrumental tests, developed on working personnel in various technical and technological areas, it was assessed the basics for a spectral comparative analysis between all the data sets, taking into account, mainly, the Noise Exposure Dose. Thus, it was shown a particular bearing that characterize a singular experimental setup. Also, it was underlined some undesirable potential behavior regarding particular spectral components of noise.*
Keywords: *Noise exposure dose, Reference limit, Acoustical comfort, Instrumental test, Indoor Acoustics.*

1. INTRODUCTION

Complaints of hearing difficulties among workers are too late an indicator that a noise problem exists. The recognition of a noise problem should take place much earlier, whenever noise levels exceed acceptable limits, or simply whenever there is a feeling that the workplace is just too noisy, particularly if there is any interference with verbal communication. In fact, the best approach is to foresee problems and avoid them; for example, by selecting quieter equipment and processes, whenever possible [1].

Noise dosimeters are widely used for monitoring noise in workplace environments where sound level may be hazardous to hearing [2]. Basically, the dosimeter integrates a weighted function of sound pressure level over a time period to determine noise dose. The noise exposure dose is a percentage of permissible exposure criteria.

Dosimeters have three basic components operating in series: a sound level meter, an integrator, and a readout device.

The overall response and quality of the sound level meter is controlled by standards, and minimum standards are usually specified by Regulations [3, 4].

Some Regulations may mandate the use of 85 dB for 8 hours as the limit for a daily noise exposure. Others consider the 80 dB as a reference limit. The measurements show the importance of these limits [5, 6].

The integrator section integrates a power function of the mean - square signal over time. The specific power function to be integrated depends on the applicable exposure criteria.

2. BASIC APPROACHES

Evaluation of noise pollution at workplace shows the way in which every person is subjected to stress due to the noise inside the production hall. A few essential parameters of these procedures are shown below

- L_{Aeq} is the level which, if maintained constant for the same period as the measurement, would contain the same amount of energy as the fluctuating noise level; "A" weighted and expressed in decibels (dBA).
- % Dose - A percentage of a fixed dose value based on the criterion level and criterion time. The criterion level and time are set by local standards. For example, some Regulations may mandate the use of 85 dB for 8 hours as the limit for a daily noise exposure. If the noise level was a constant 85 dB for 8 hours, this would generate a %Dose of 100%.
- Estimated Dose: Estimates the % dose that would have been received by the wearer if the average level measured had existed for the period defined by the criterion time. For example, if for a 4 hour measurement the % Dose was 50%, the Estimated Dose would be 100% for the 8 hours of the Criterion Time.
- LAE or SEL: The level which, if maintained constant for a period of 1 second would have the same sound energy as that actually received by the doseBadge during the measurement period.
- Threshold: Sound Levels below the threshold are excluded from all averaging.

The equivalent continuous sound level L_{Aeq} can be evaluated using [7]

$$L_{Aeq} = 10\log_{10}\left[\frac{1}{T_c}\int_0^T\left(\frac{p_A(t)}{p_0}\right)^2 dt\right] \tag{1}$$

where:

- T_c is the criterion sound duration (usually 8h);
- T is the measurement duration [h];
- $p_A(t)$ is time varying instantaneous A-weighted sound pressure [Pa];
- p_0 = 20 [μPa];
- t denote time [h].

A rather general expression which mathematically describes the noise exposure dose operation is

$$D = \frac{100}{T_c}\int_0^T 10^{\frac{L-L_c}{q}}\, dt\text{, [\%]} \tag{2}$$

where

- D is percentage exposure [%];
- t denote time [h];
- L is the sound level - as a function of time (usually dBA);
- L_c is the criterion level (usually dBA);
- q denote the criterion exchange rate parameter [dB].

For discrete time intervals at a constant sound level the Eq. (2) become

$$D = \frac{100}{T_c}\sum_{i=1}^{n} t_i\ 10^{\frac{L_i-L_c}{q}}\text{, [\%]} \tag{3}$$

where L_i is the weighted sound level in the i^{th} time interval (usually dBA) and t_i denote the time spent in the i^{th} interval [h].

The exchange rate parameter q is generally related to the exposure accumulation factor of the criteria. The parameter q usually acquires 10 values for an exchange rate of 3 dB. With the 3 dB exchange rate a dose of 100% equates to 90 dBA and 200% equates to 93 dBA where as with the 5 dB exchange rate 200% equates to 95 dBA. With an exchange rate of a 3 dB increase being equivalent to a doubling of exposure time, a noise exposure level of 96 dBA would read as 400% noise dose.

With respect the criterion level L_c, 90 and 85 dBA are most often used.

In Fig. 1 were depicted two common cases of equivalent sound level evaluation (for dose exposure) in the same workplace, but for two different workers. Multiple peaks on the first diagram (red dots on the picture) reveal the full over load regarding the criteria level. The second diagram presents a few small area with "red dots" that means in most of the time the level do not exceed the criteria level.

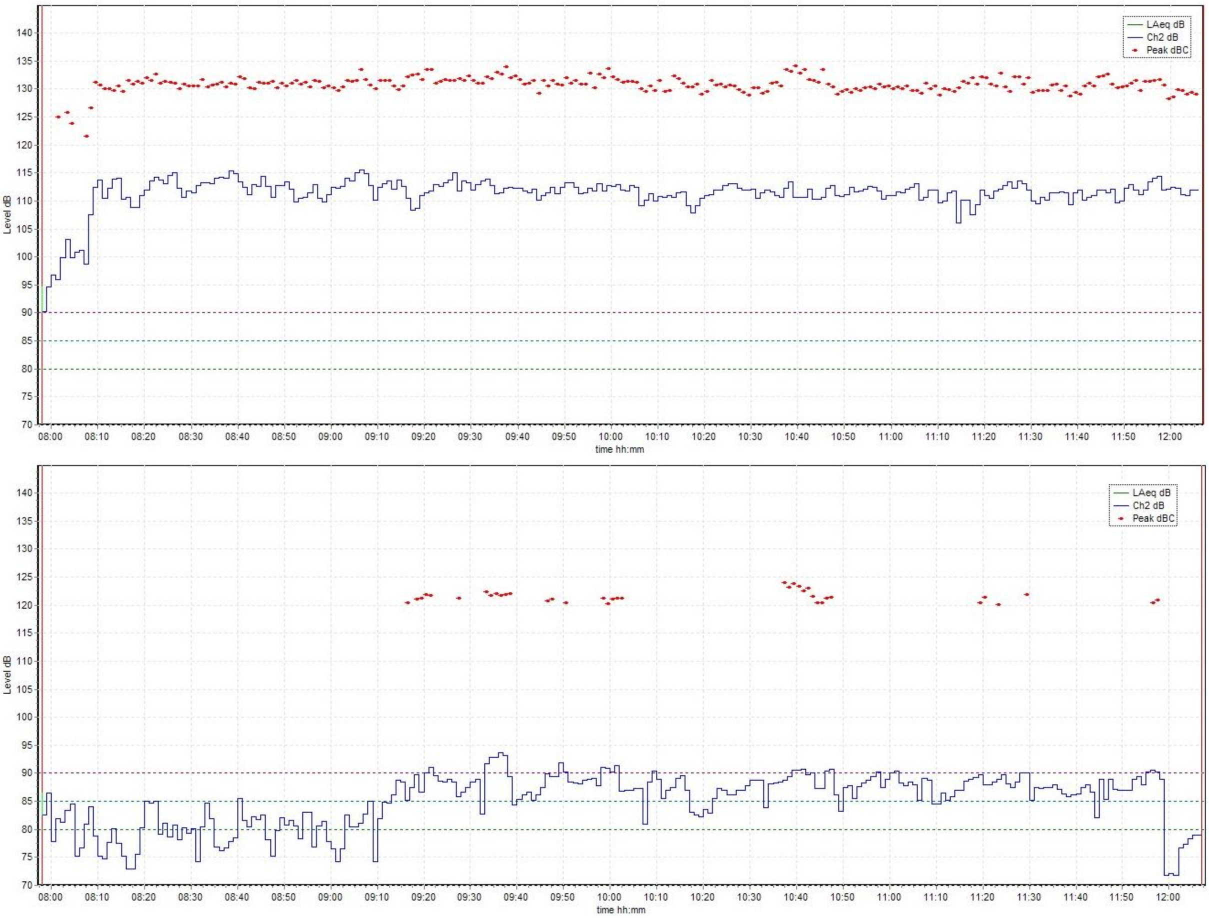

Fig. 1. Two cases of equivalent sound level evaluation (continuous, 4h).

Also, in Fig. 2 is depicted a short time example of equivalent sound level estimation, and for another workplace. This example was made just for the presentation of the next paragraph ideas, without any other consideration. Analyzing the diagram on the upper side in Fig. 2 results that only for a few times the equivalent level exceeds the criterion level. The second diagram on Fig. 2 depicted the 1/3 octave band spectrum for a certain position of cursor in upper diagram.

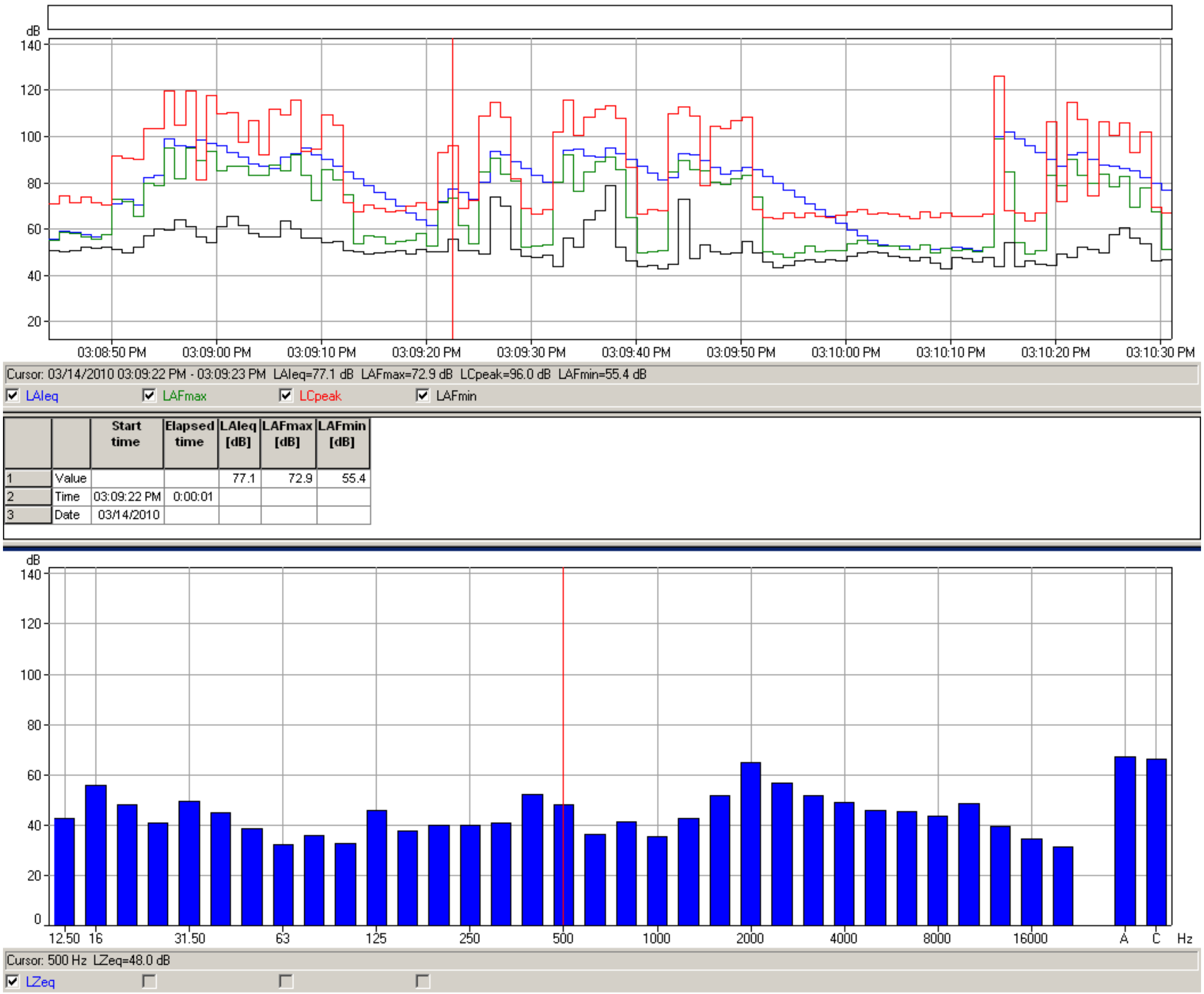

Fig. 2. Equivalent sound level evaluation for a short time acquisition.

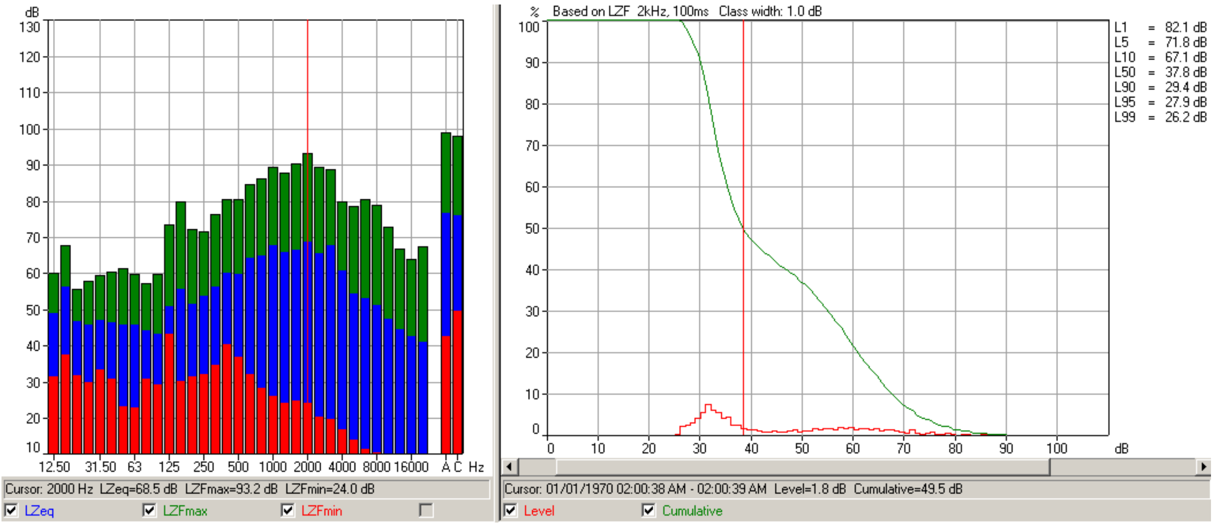

Fig. 3. Diagrams of statistic analysis of equivalent sound level.

Fig. 3 presents statistic analysis of the same recording such as in Fig. 2. From these diagrams could be estimate the specific values for a lot of spectral parameters, but it cannot evaluate the exposure dose value for a spectral domain. Also, it is difficult to evaluate if for a moment of time, and for a spectral component, the equivalent level exceed the criteria limit.

3. COMPUTATIONAL RESULTS

The software attached to specialized equipments for sound acquisition and analysis presents an advantage through saving initial data on some usual file format. This feature is very helpful for processing and analysis with the other software packages [8].

The measurement data presented in Fig. 2 was processed with special mathematical software and the results were depicted in Figs. 4-6. In Fig. 4 is the Z-weighted equivalent sound level represented as a function of frequency and time. Thus, it was dignified the potential dangerous areas where the level could be exceed the criterion limit or not.

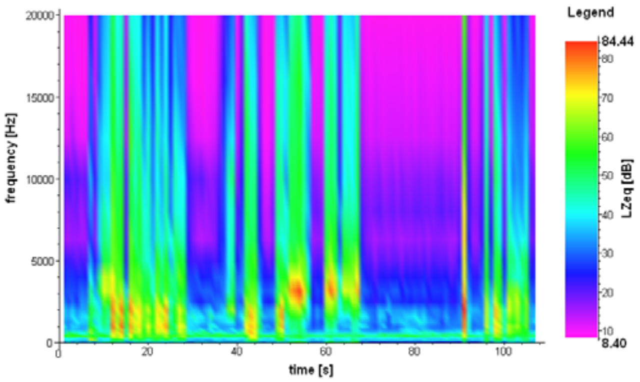

Fig. 4. Z-weighted equivalent sound level as a function of frequency and time (for measurement depicted in Fig. 2; full linear scale).

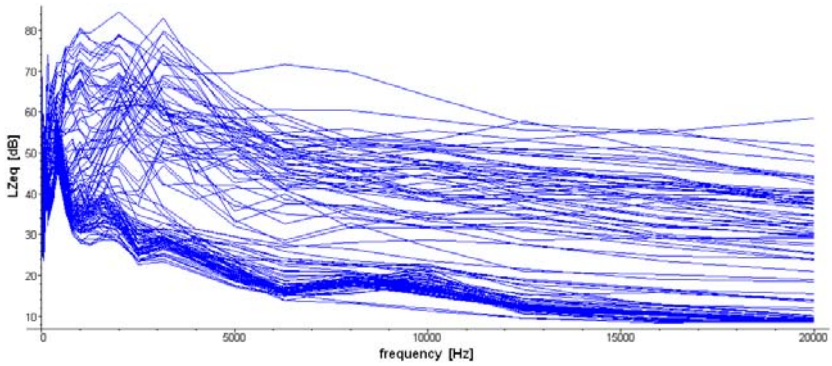

Fig. 5. Spectral composition of Z-weighted equivalent sound level (for measurement depicted in Fig. 2; full linear scale).

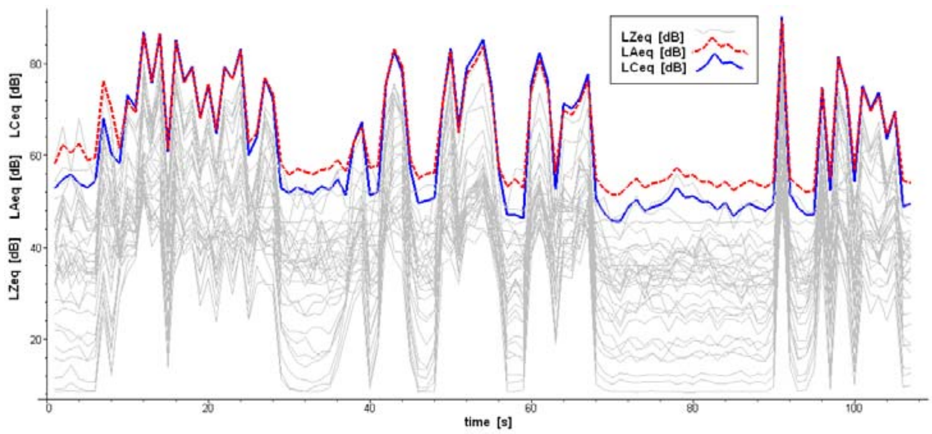

Fig. 6. Timed evolution of Z, A, C-weighted equivalent sound levels (for measurement depicted in Fig. 2).

In Figs. 5 and 6 was depicted the spectral composition of Z-weighted equivalent sound level, respective the timed evolution of Z, A, C-weighted equivalent sound levels. The diagrams package in Fig. 5 has the advantage of easiness in estimation of potential dangerous area in spectral coordinates. The superposition of graphs in Fig. 6 dignifies the local areas where the equivalent sound level exceeds the criteria limits (A or C -weighted sound levels).

4. DISCUSIONS AND CONCLUDING REMARKS

The recognition that a noise problem exists is followed by a qualitative assessment of the situation, which includes identifying and localizing noise sources, defining noise exposure patterns, including which are normal and which are unusual exposure conditions. In view of their experience with tasks, work processes, equipment and machinery, workers can provide valuable assistance in gathering such information, which is needed to design an adequate strategy for any subsequent quantitative evaluations, in this case, noise surveys.

This work was born from serviceable necessity, had a strong base on various and multiple experimental tests, and was supplied and validated with benefits of computational acoustics means. But, it is not a comprehensive study; it will be continued with many others tests and, finally, with an operational methodology designated to eliminate or, at least, to diminish the uncommon and particular aspects from the noise pollution characterization through the Noise Exposure Dose.

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